1) RNN Families & Use-Cases (Many-to-X)

a) Task-to-RNN I/O Pattern Mapping:

Task	Suitable RNN Pattern	Explanation
Next-word prediction	**Many-to-one**	The model takes a sequence of previous words (many inputs) and predicts the next single word (one output).
Sentiment of a sentence	**Many-to-one**	The entire sentence (sequence of words) is processed to produce one sentiment label (positive/negative/etc.).
NER (Named Entity Recognition)	**Many-to-many aligned**	Each input word corresponds to an output label (e.g., PERSON, LOCATION), so outputs align with inputs.
Machine translation	**Many-to-many unaligned**	The input sequence (source language) and output sequence (target language) differ in length and alignment.

b) Unrolling Explanation:
Unrolling an RNN over time allows **Backpropagation Through Time (BPTT)** by treating each time step as a layer with shared weights, enabling gradient flow across all time steps.

c) Weight Sharing – Advantage & Limitation:

- **Advantage:** Reduces the number of parameters, improving generalization and efficiency.

- **Limitation:** Limits flexibility—same weights are used even when different time steps may require different transformations.